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North Dakota State Water Commission

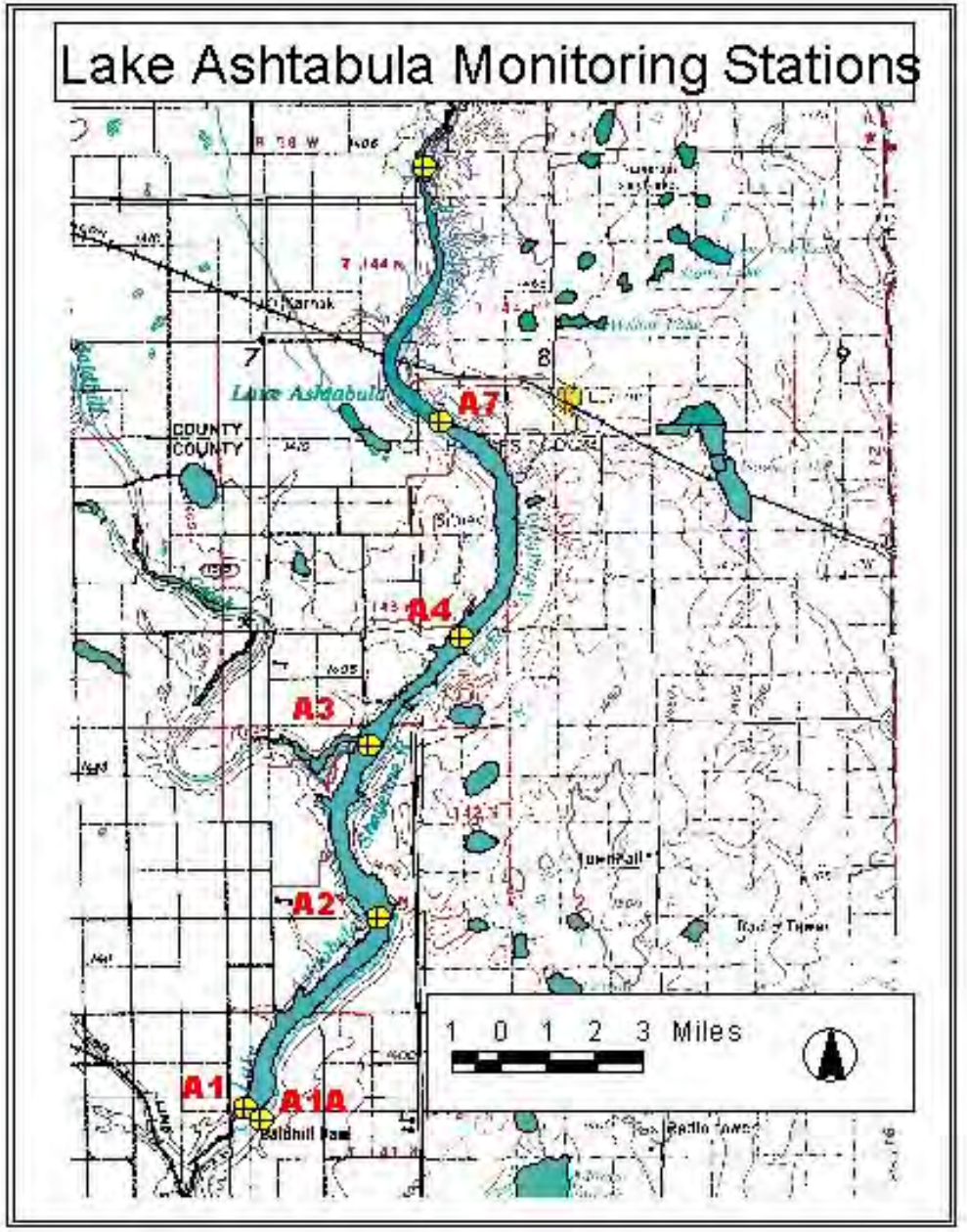
Monitoring and Modeling The Effects of Proposed Increase in Devils Lake Outlet Capacity on Future Flows and Sulfate Concentrations in the Upper Sheyenne River and Lake Ashtabula

Evaluation and Modification of Existing Monitoring Network

- Analyze recent water-quality data (both discrete samples and continuous monitors) to determine if there are gaps or inadequacies in the monitoring data that need to be filled
- Collect detailed synoptic water-quality data from Lake Ashtabula
- Use the synoptic data along with existing field samples and real-time streamflow and water-quality monitoring data to characterize spatial and temporal variability of sulfate and other constiuents in Lake Ashtabula
- Determine an efficient data collection network for future operation and monitoring of the outlet

Existing Data

- Samples collected by USACOE for the NDDH
- 6 sampling sites
- Data available from approx. 1991-2006



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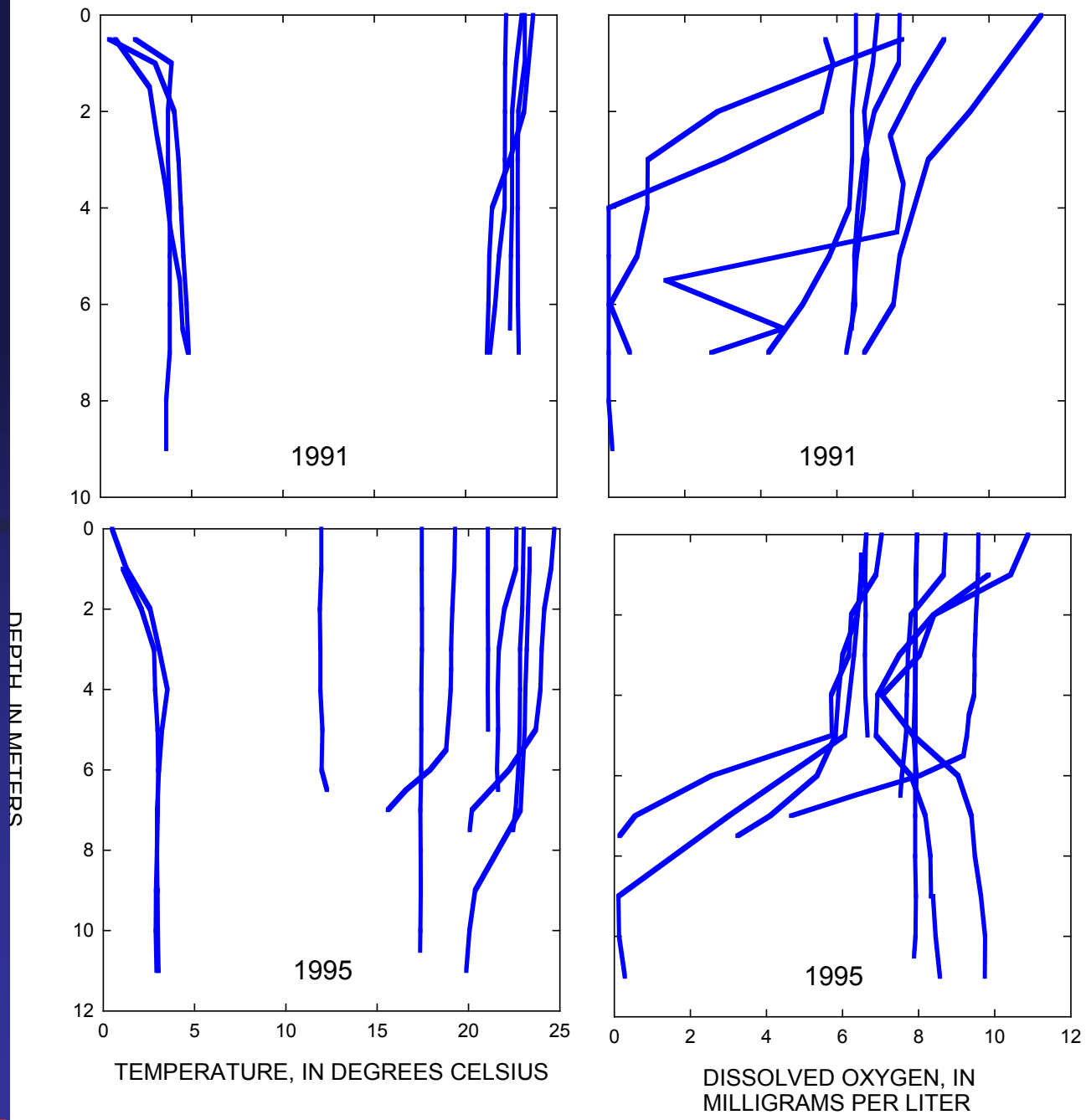
USACOE Sampling

- Site A1 –near the Dam has real-time water-quality profiler
- Temperature and DO varies vertically



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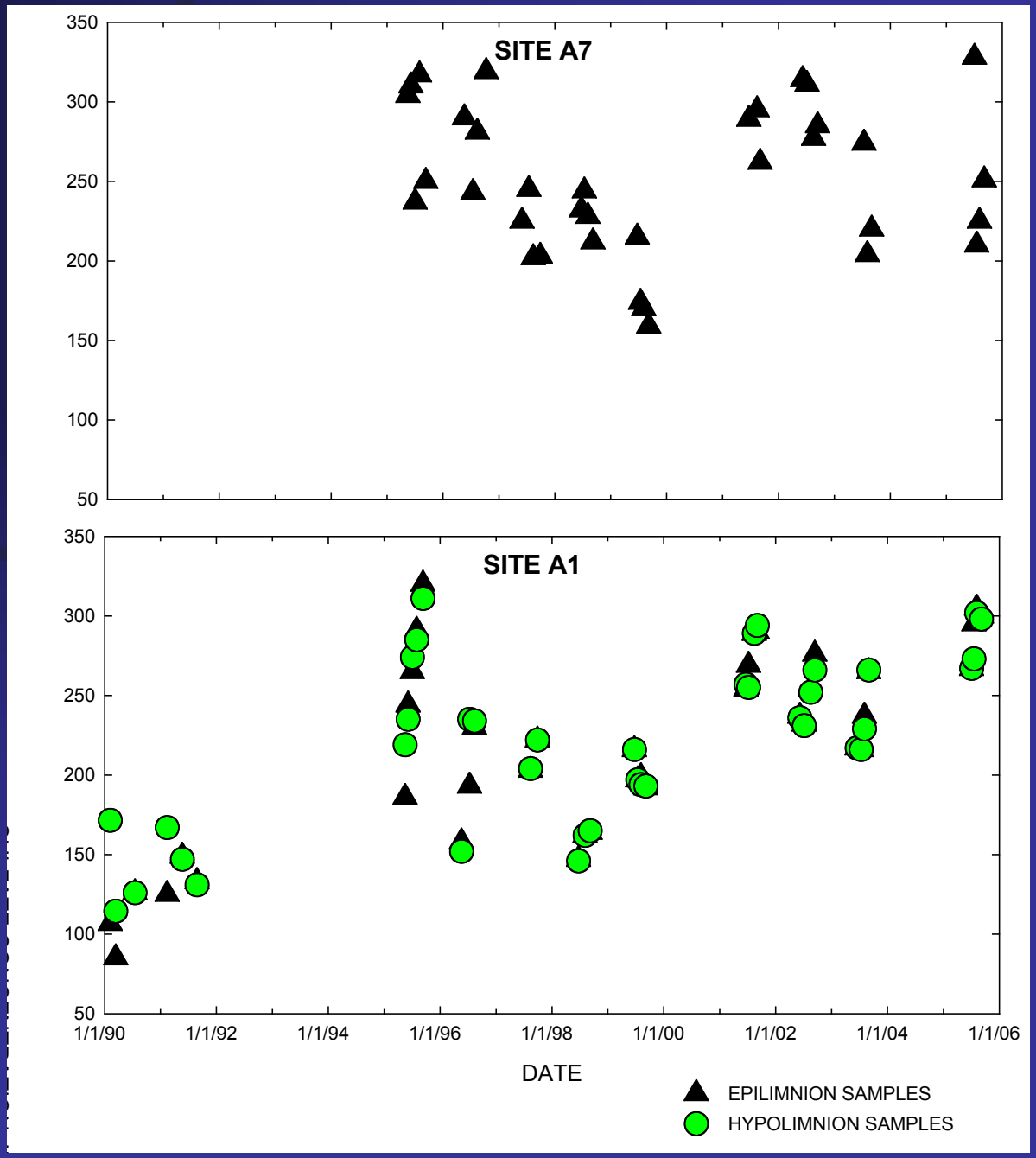
USACOE/NDDH Data



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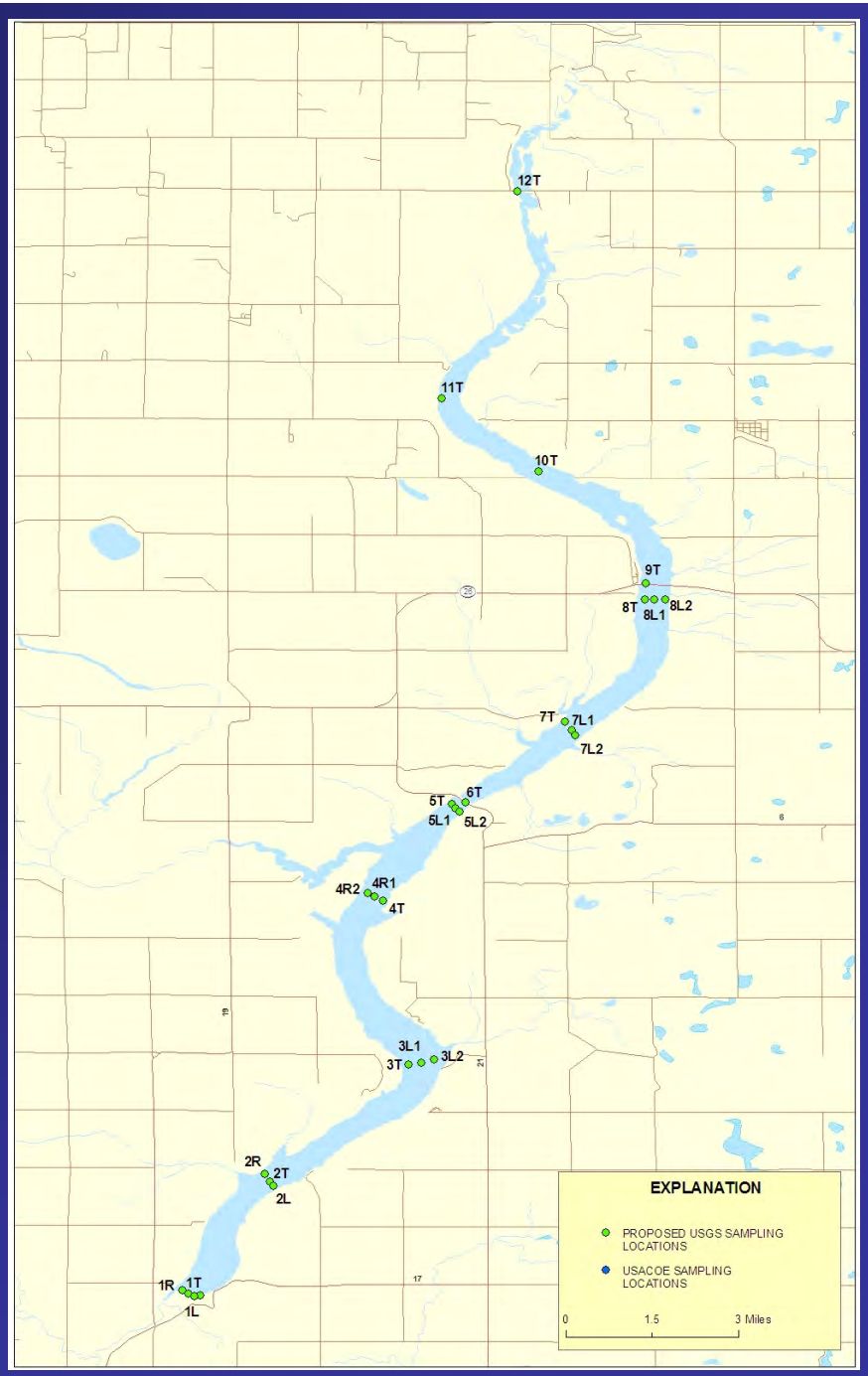
Synoptic Sampling Locations

- 26 sampling locations
- Samples collected 1 m above bottom and 1 m from surface
- Samples collected in Sept., Oct., and February (during full ice cover)
- Vertical profiles collected
- Samples analyzed for nutrients, major ions, and trace metals –NDDH laboratory



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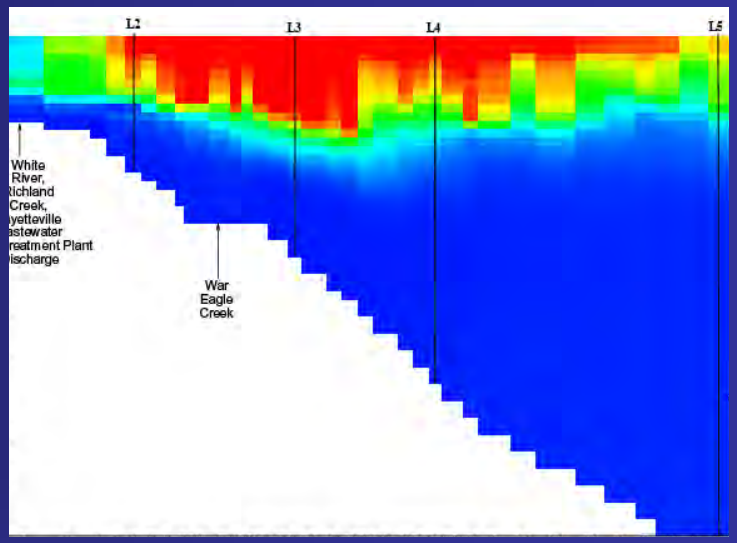
Development of Real-time Model for Use in Operating and Monitoring the Outlet

- Calibrate and verify a hydrodynamic and water-quality model for Lake Ashtabula
- Couple the model with the Devils Lake outlet simulation model



- Develop a real-time model as a decision-support tool for the NDSWC for operating and monitoring the outlet

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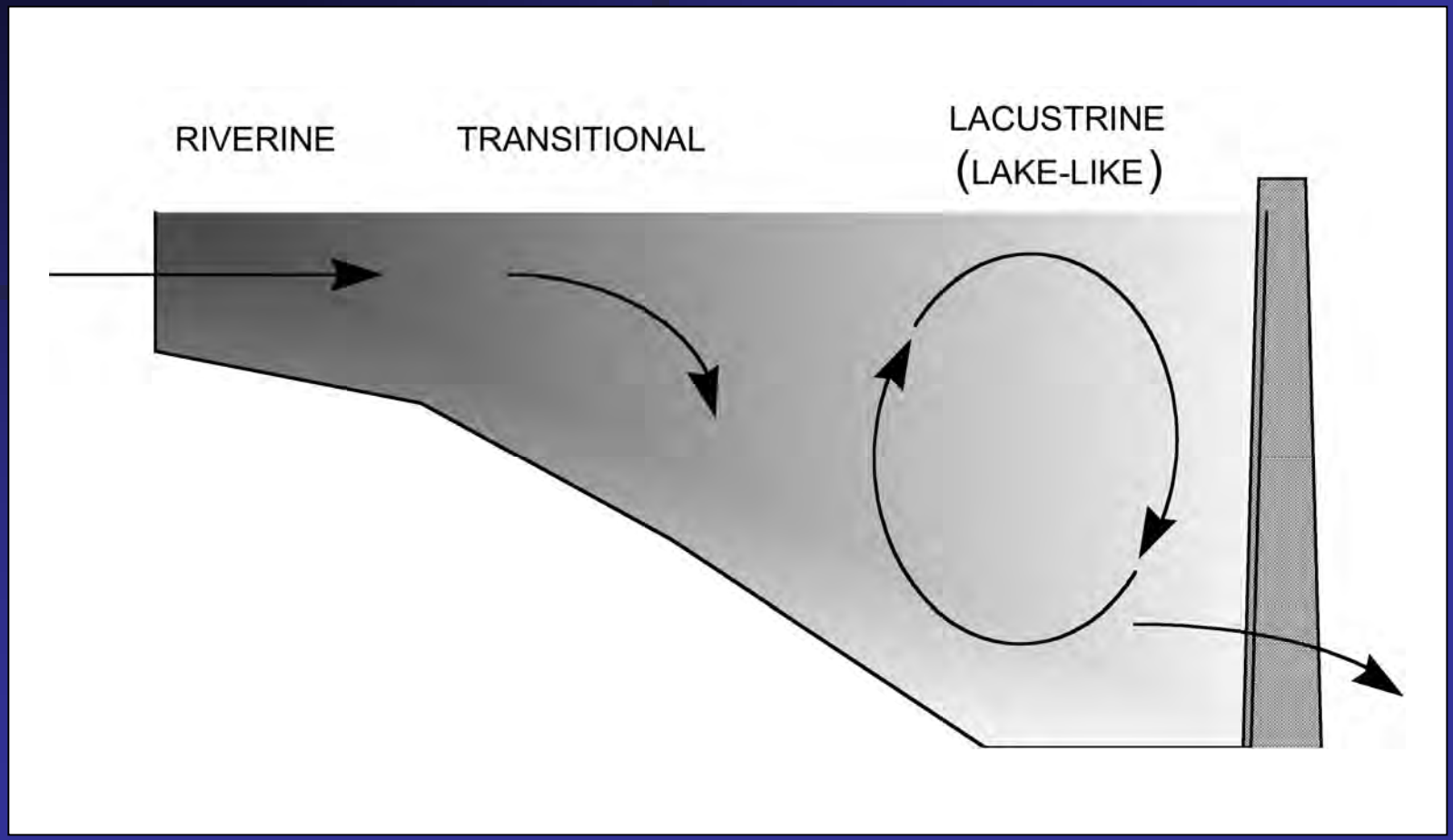
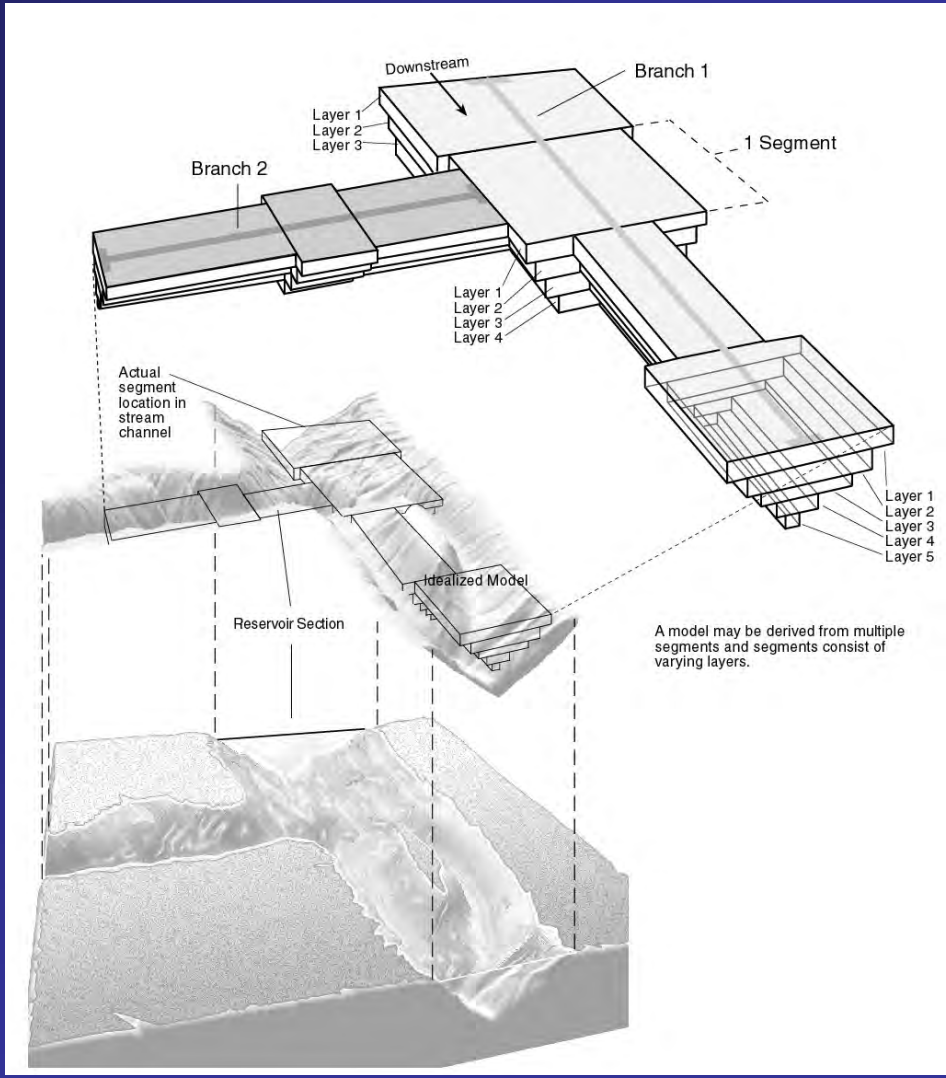
Reservoir Dynamics



Reservoir Water-Quality Model: CE-QUAL-W2

- Two Dimensional
  - Downstream (longitudinal)
  - Depth (vertical)
- Laterally Averaged
  - Homogenous within grid cell
- 18 state variables (in addition to temperature) – nutrients, organic matter, suspended solids, DO, phytoplankton, TDS
- 60 derived variables
- Capable of simulating riverine water bodies
- Conservation of Mass
  - Sources and
  - Sinks



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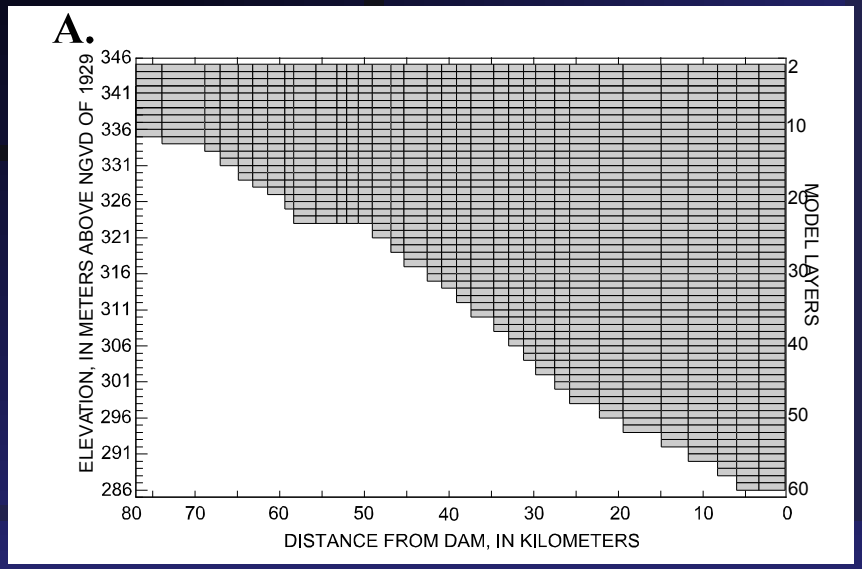
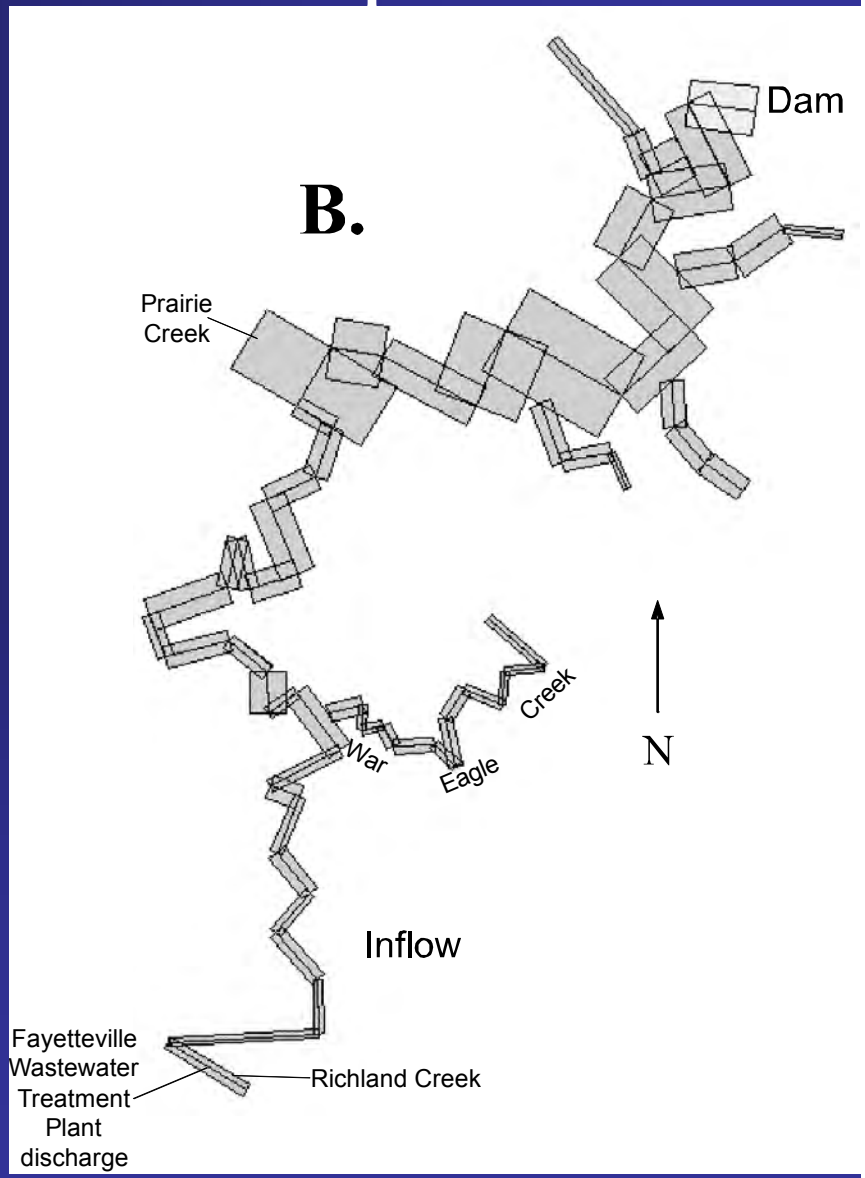
Cole, T.M.and Wells, S.A., 2003, CE-QUAL-W2: A two-dimensional, laterally averaged, hydrodynamic and water quality model, version 3.1, U.S. Army Corps of Engineers Instruction Report [DRAFT] EL-03-01.

Computational Grid – Beaver Lake

Side View – Main Branch

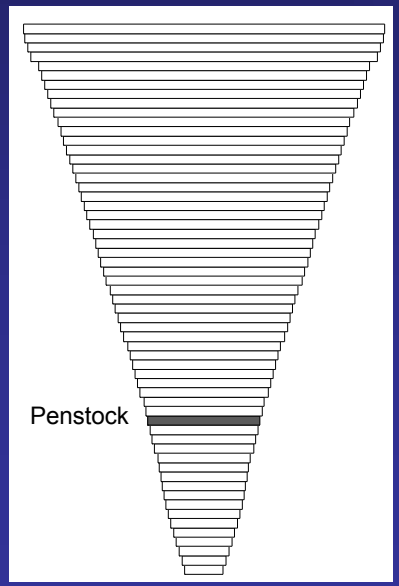


Top View



Model geometry

- 6 branches
- 59 segments
- 1 meter layers
  - Reservoir bottom ranged from 10 to 60 m deep



Dam View

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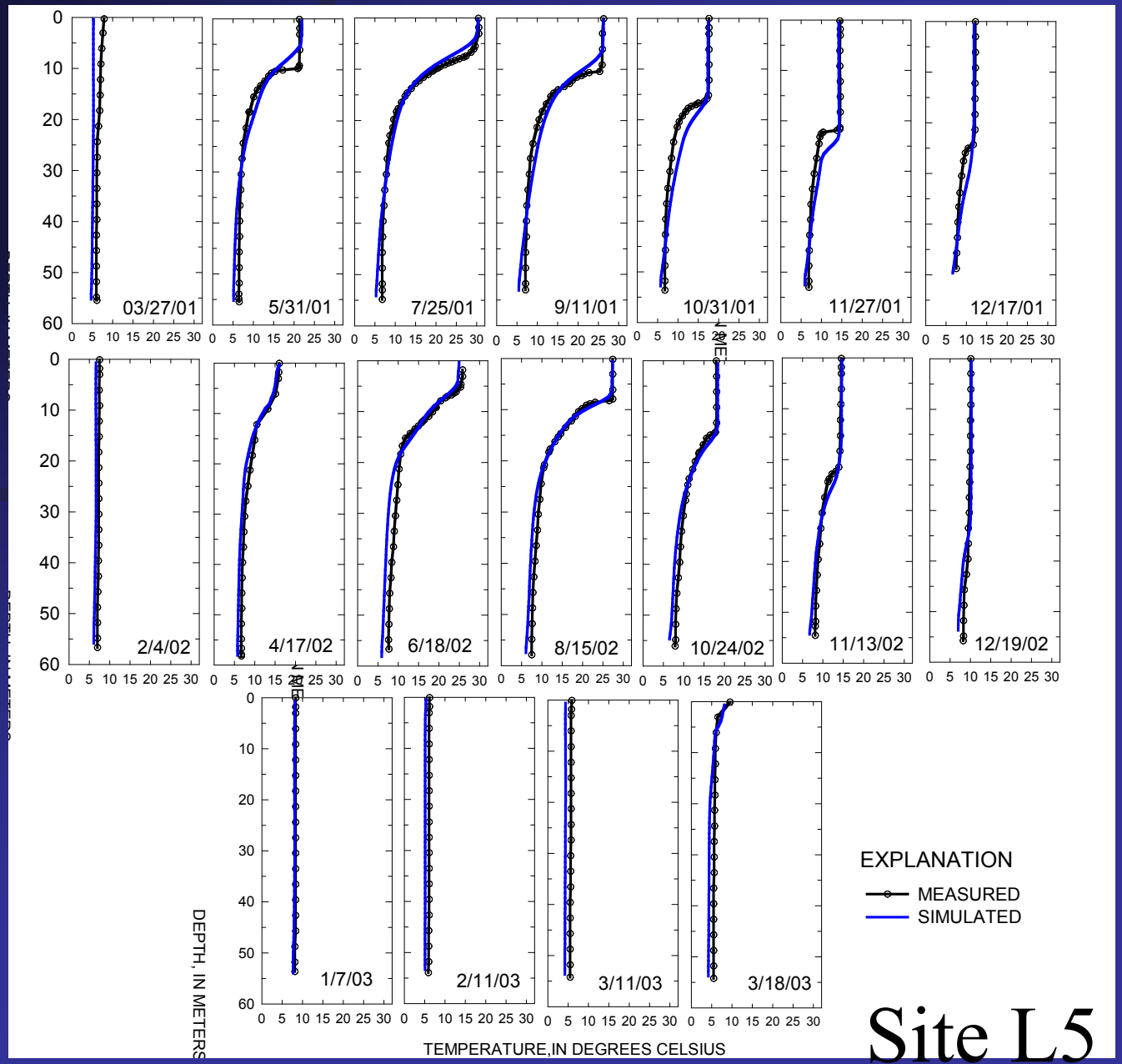
Temperature Calibration –Beaver Lake

Model Error:
AME ranged from 0.8 (L5) to 1.7°C (L2) for 2001-2003



Site L5

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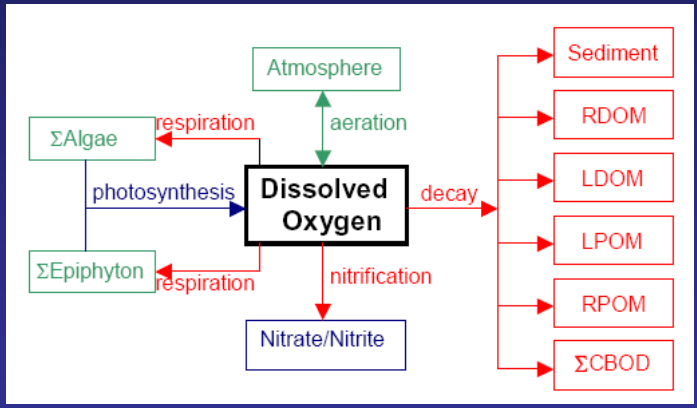
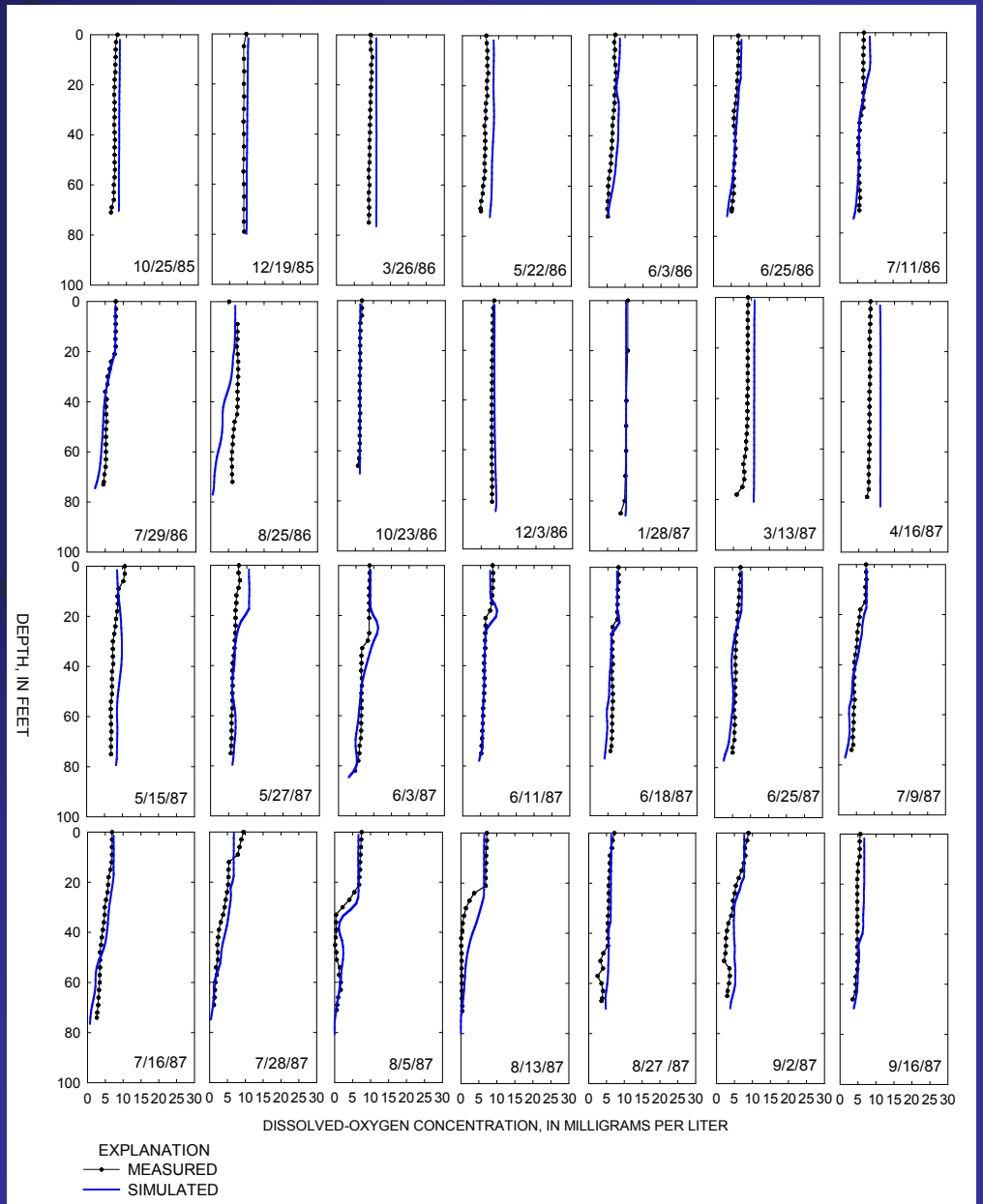
Dissolved-Oxygen Calibration – Pueblo Reservoir

- AME = 1.14 mg/L
- RMSE = 1.30 mg/L



SITE 5C –Segment 19



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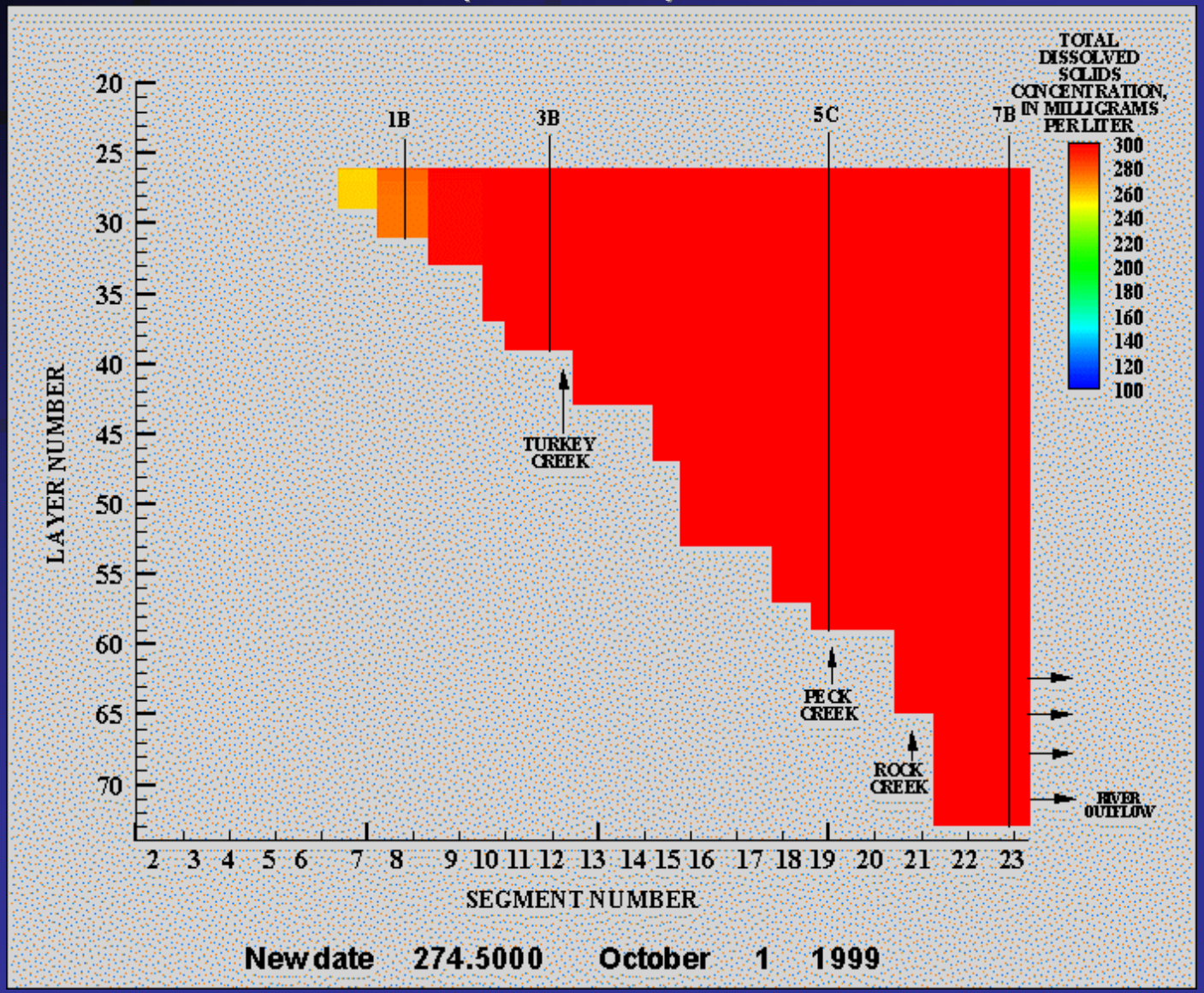
Total Dissolved Solids – Pueblo Reservoir

(animation)



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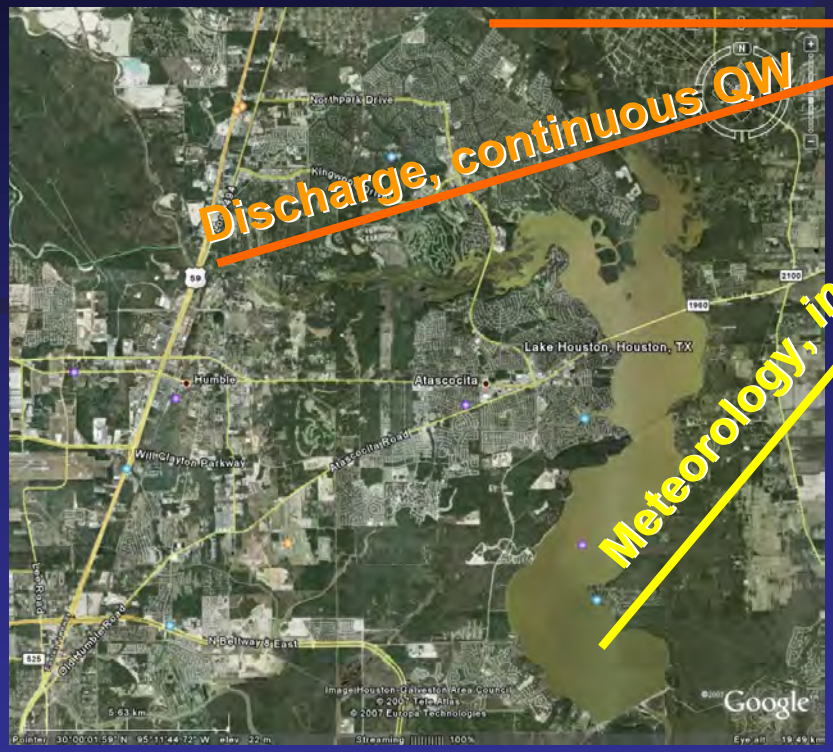
Automated Real-Time Controls



GSM / GOES Date Telemetry

Database Server

Modeling Server

- Run 3-D Models, Real-Time 7-Day updates
- Run Real-Time Simulations

WEB Display

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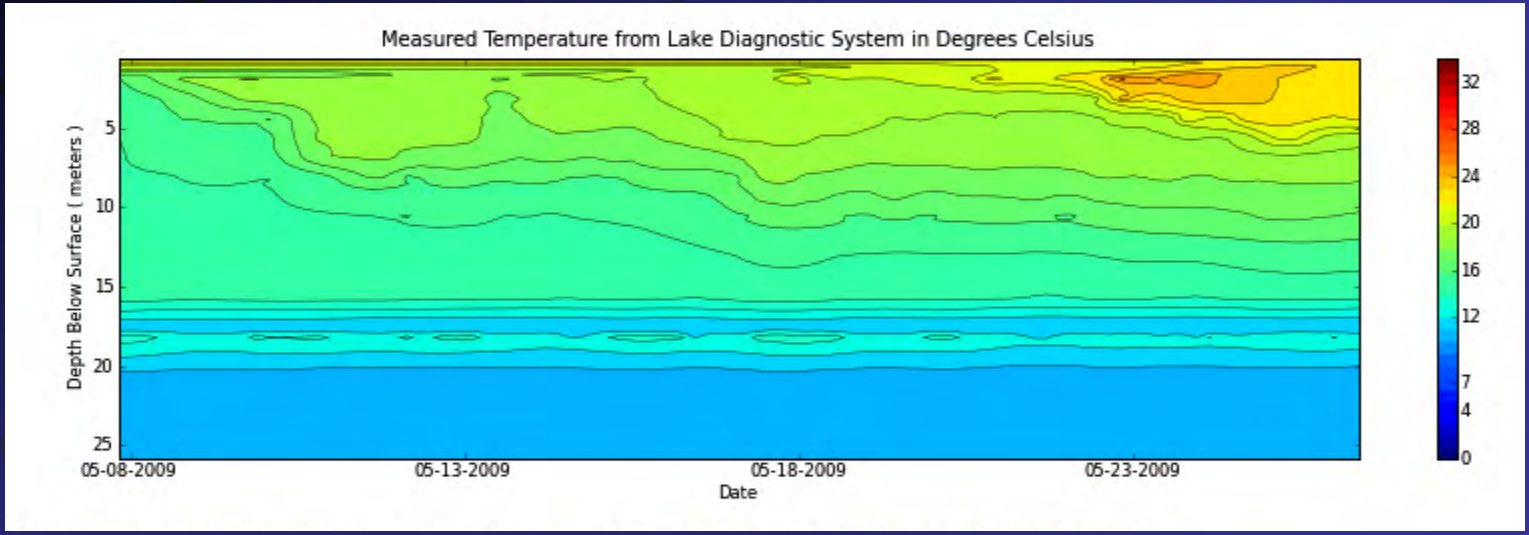
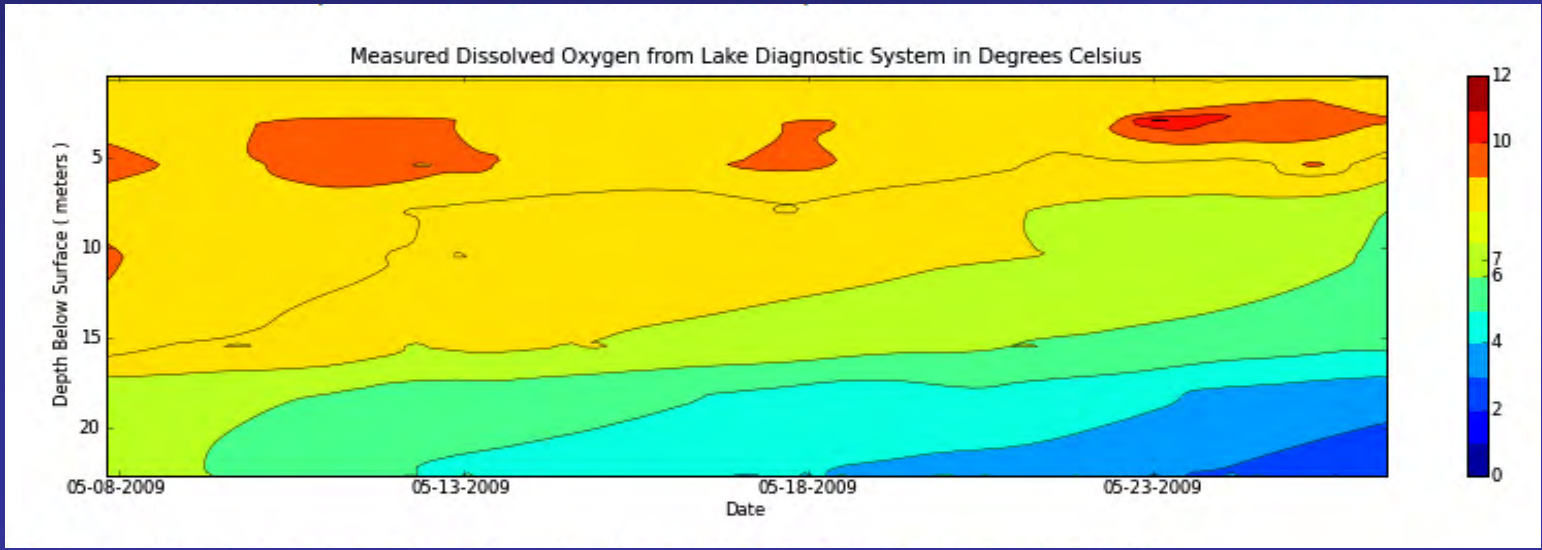
Web-Based Real-Time Data





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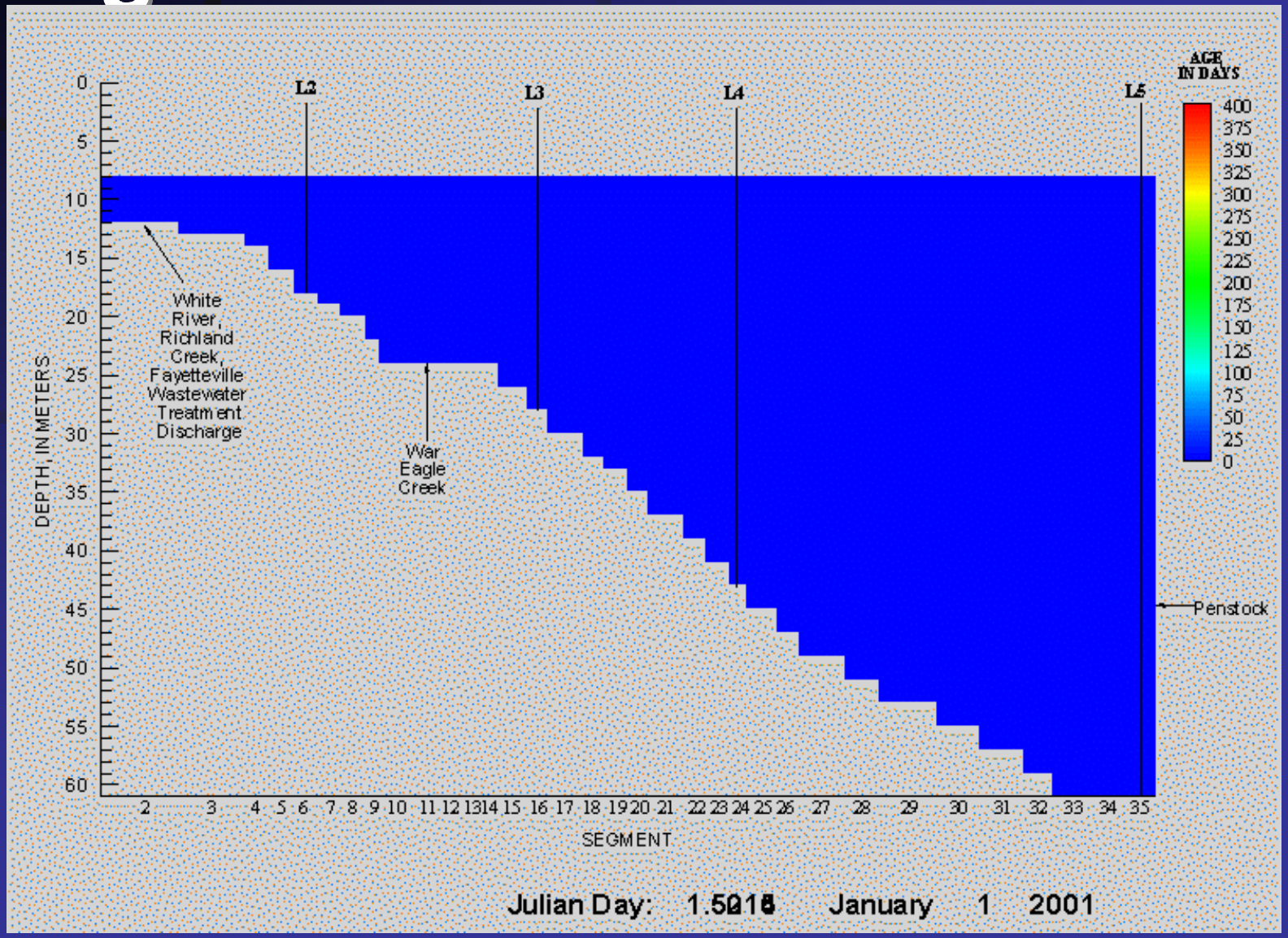
Age of Water –Beaver Lake



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http://ar.water.usgs.gov/beaver_lake/

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Data Center

Real-time data
- Streamflow
- Ground water
- Water quality
- Precipitation

Historical data

On the Web
- Streamflow
- Streamflow (instantaneous)
- Ground water
- Water quality
- Annual Data Reports
- USGS Water Data Reports

By Request
- Water use

WaterWatch
- National Download Google Earth files of streamflow

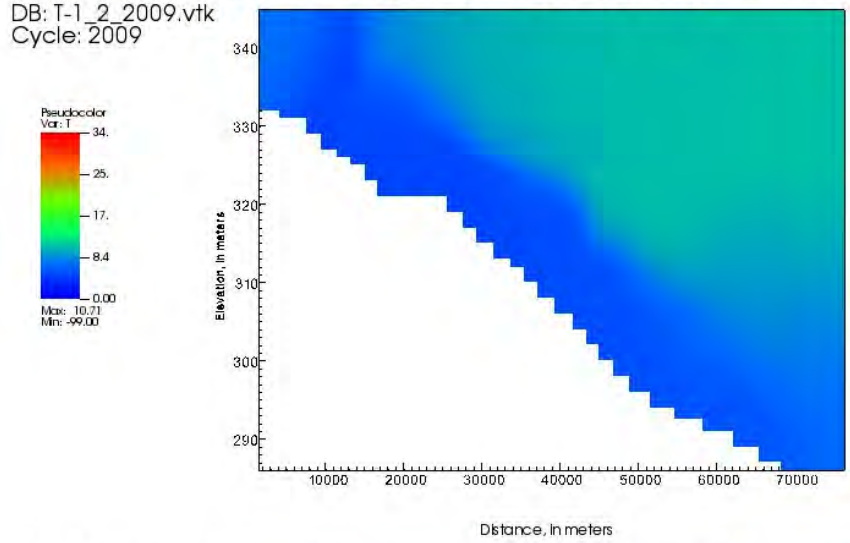
Two-Dimensional Real-Time Beaver Lake Modeling System

Real-time data are collected at a location on Beaver Lake near Lowell, Arkansas by a lake diagnostic station (LDS) The LDS has been in operation since January 30, 2008. Real-time data include air temperature, relative humidity, wind speed and direction, shortwave and net longwave radiation, water temperature at 16 depths in the water column, and dissolved oxygen concentrations at 8 depths in the water column. Data are recorded every 30 seconds and transmitted hourly to the USGS Arkansas Water Science Center website (http://ar.water.usgs.gov), station number 07049200.

The real-time data from the LDS is used to run an existing two-dimensional model of hydrodynamics and water quality in Beaver Lake that has been developed and published by the USGS in cooperation with Beaver Water District, Arkansas Department of Environmental Quality, Arkansas Natural Resources Commission, U.S. Environmental Protection Agency, and U.S. Army Corps of Engineers for Beaver Lake (http://pubs.usgs.gov/sir/2006/5003/SIR2006-5003.pdf , and http://pubs.usgs.gov/sir/2006/5302/pdf/SIR2006-5302.pdf).

The animations below show a side view (the White River flows in from the left and Beaver Lake Dam is on the right) of simulated water temperature and dissolved oxygen in Beaver Lake for the last 30 days.

Simulated Water temperature, in degrees Celsius (30-day loop) Measured Data



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